GLOBAL IONOSPHERIC SPECIFICATION FROM GPS AND AIRGLOW DATA

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LONG-TERM GOAL

The long term goal of the project is to produce real-time global ionospheric specification with data and appropriate interpolation models. This will initially be accomplished by ingesting data from ground-based GPS receivers and space-based airglow sensors, although other types of sensors may enter later. The model will provide proper weighting to the location and time, as well as to the sensor.

SCIENTIFIC OBJECTIVES

We have developed a technique to specify driving parameters (e.g., effective sunspot number) of a global climatological ionospheric propagation model (RIBG) from GPS data (Reilly and Singh,1997). Predictions from the GPS data-driven RIBG model have been tested by independent data to show that this technique performs well for mid-latitude ionospheric specification, but not as well for lower latitudes. The first objective of the project was improve performance by including an improved low latitude model in RIBG. Secondly, an initial software implementation of the technique was tested by JPL to update ionospheric conditions on an hourly basis for all global GPS stations, but it was too slow to keep up with data throughput requirements. Our second objective was to make the technique much faster and more robust, to solve this problem. The third objective of the project was to investigate the feasibility of combining the GPS data with space-based ultraviolet airglow measurements for global ionospheric specification.

APPROACH

To improve the accuracy of our ionospheric model at equatorial latitudes, we have collaborated with Dr. Michael Keskinen of Naval Research Laboratory, to adapt his low latitude model, still in progress, to Geoloc's ITRAY (Ionosphere and Troposphere Raytrace) model, the successor to RIBG. ITRAY presently specifies the ionosphere with three driving parameters: SF2 (effective sunspot number for foF2), SM3 (effective sunspot number for M3000), which determines the height and width of the F2 layer, and CFAC (a parameter for the topside profile). The equatorial anomaly exhibits asymmetry on the two sides of magnetic equator. Our approach is to specify

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one or more additional driving parameters (e.g., meridional component of neutral wind velocity and an electric field component), which would help to reproduce observed equatorial anomaly characteristics. To help achieve the second objective of making our model much faster and robust, we plan to introduce Kalman filtering and other improvements. To meet the third objective, we are in the process of obtaining coincident GPS and airglow data for observations in the same region, for comparison of ionospheric specification results and for formulating the global specification strategy.

RESULTS

The technique we have developed to specify the ionosphere from GPS data avoids both the questionable approximation of the conventional thin ionospheric shell model for mapping from vertical to slant TEC and the approximation of the ionosphere rotating unchanged with the sun about the magnetic dipole axis. The result is significantly improved specification out to greater distances from a GPS receiver, which impacts the density of GPS receivers requirement for global specification.

For investigation of our technique and the model at low latitudes, we have acquired Jicamarca incoherent scatter radar (11.9 S, 76 E) data for the 7-12 October 1996 MISETA campaign. A Faraday double-pulse technique was used to obtain electron density profiles at 15 minutes intervals, without the need for external calibration. We have compared some of the electron density profiles with climatological models, RIBG, ITRAY, IRI-90, and other models available to us. The GPS station selected to determine the effective sunspot number input to these models was Arequipa (16.46 S, 71.49 E) in Peru. The comparison of the observed electron density height profile data for 9 Oct,1996 with the ITRAY model prediction is shown in Figure 1, on page 3. The dots are observed data between 1400-1600 LT and the two lines are the model values at 1400 LT and 1600 LT. The results show that ITRAY predicts foF2 and the bottom-side region quite well. With the default value of CFAC (0.86) the model overestimates the topside density, but does better than other ionospheric models (e.g., IRI-90) in this regard. Treating CFAC as an adjustable parameter would produce a very good topside fit. One of the most interesting and persistent features of the data, up to now, has been the extraordinarily high value of foE. The electron density at the E-region peak substantially exceeds that at the F2 peak. At this time, no climatological model exhibits this feature. This is of interest for low latitude model development.

We have dramatically improved code speed, by tenfold over the initial software implementation delivered to JPL, which should satisfy data throughput requirements, and further improvements with Kalman filtering are anticipated. We have also developed a technique to extract the ionospheric specification from a single-frequency GPS receiver, and have shown (Reilly & Singh, 1997) increased range of specification from a single receiver, which should dramatically cut costs of a global deployment of GPS receivers.

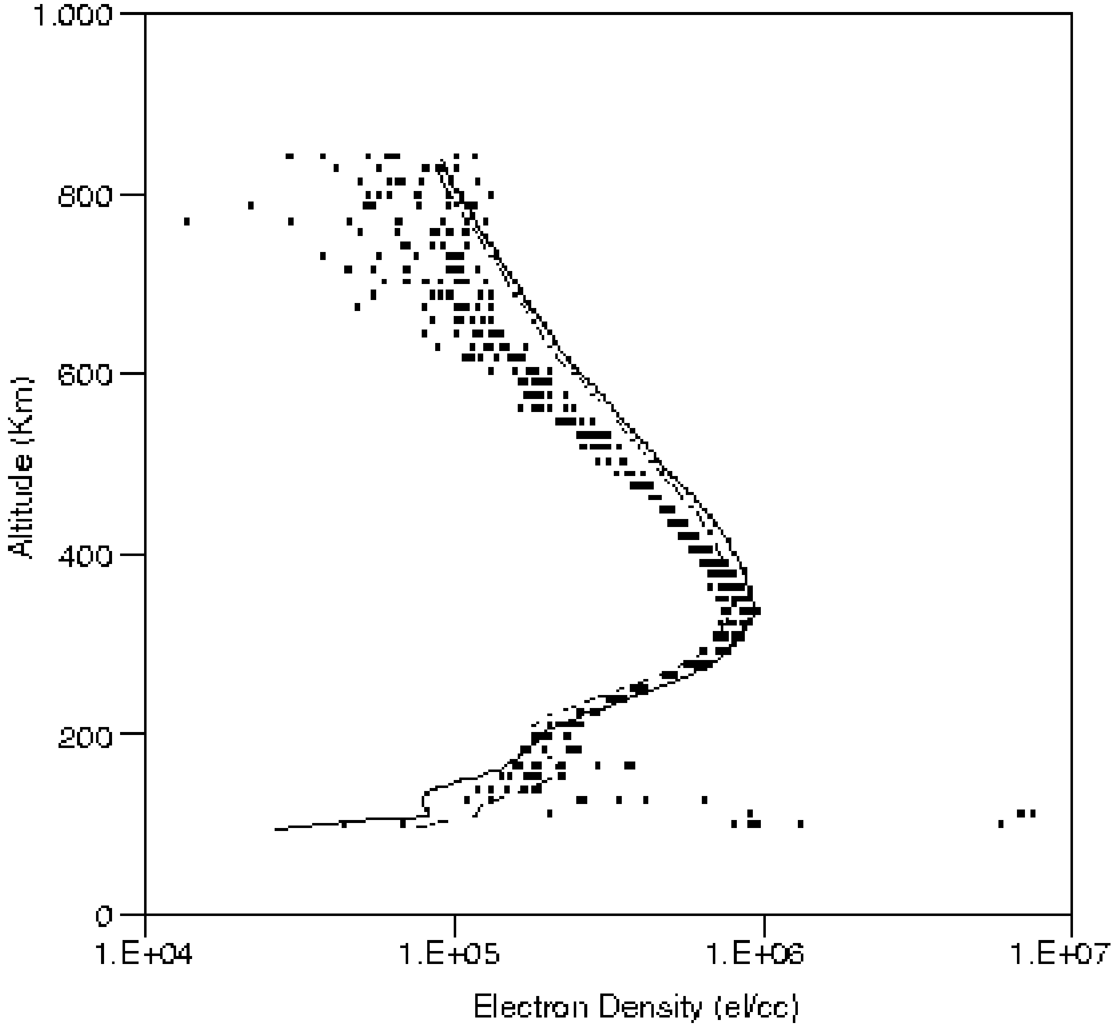

Figure1. Jicamarca Radar Electron Density Profiles for 9 Oct.,1996 during 1400 - 1600 LT (dots) and ITRAY Prediction at 1400 LT (red, upper line in topside) and 1600 LT (green line)

IMPACT/APPLICATION

The problem stated in the ‘Long-Term Goals” section is an example of a classic one in remote sensing, and its solution should be of great interest in remote sensing science. Global ionospheric specification would enhance the accuracy of radio systems, especially those which operate at the lower frequencies. Further global ionospheric specification in real-time from various sensors should itself provide a valuable database for understanding solar-terrestrial relations.

TRANSITIONS

Global ionospheric specification is presently of interest to the surveillance systems of DOD, to GPS navigation systems, and for communication systems. The software implementations developed here are directly transferable.

RELATED PROJECTS

Geoloc is in a project for the geolocation of single frequency GPS receiver with improved accuracy, which benefits from improved ionospheric and tropospheric specification. Geoloc is also involved in other DOD geolocation projects, which also benefit from this.

REFERENCES

Reilly, M.H., and M. Singh, 1997. “Ionospheric specification from GPS data and the RIBG ionospheric propagation model,” *Radio Sci*., 32(4), 1671-1679.